AD-A102 090   NAVAL RESEARCH LAB WASHINGTON DC   F/G 18/4

ENVIRONMENTAL MONITORING FOR GAMMA RADIATION AT THE NAVAL RESEA--ETC(U)

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REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER: NRL Memorandum Report 4561	2. GOVT ACCESSION NO.: AD-A102 090	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle): ENVIRONMENTAL MONITORING FOR GAMMA RADIATION AT THE NAVAL RESEARCH LABORATORY – 1980		5. TYPE OF REPORT & PERIOD COVERED: Interim report on a continuing NRL problem.
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s): K. J. King		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS: Naval Research Laboratory, Washington, DC 20375		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS: 76056-7201
11. CONTROLLING OFFICE NAME AND ADDRESS		12. REPORT DATE: July 17, 1981
		13. NUMBER OF PAGES: 9
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)		15. SECURITY CLASS. (of this report): UNCLASSIFIED
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Environmental monitoring
Background radiation
Thermoluminescent dosimeters

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The gamma radiation levels at the Naval Research Laboratory were monitored during the calendar year 1980 at the perimeter of the Laboratory as well as areas where sources of radiation were used or stored. The measurements were made using $CaSO_4$:Dy Thermoluminescent dosimeters which were determined to have a reproducibility of ± 6% (1 S.D.) for each individual dosimeter disc. The results show that the Laboratory has met the requirements of the applicable regulations for radiation levels at an unrestricted area.

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ENVIRONMENTAL MONITORING FOR GAMMA RADIATION
AT THE NAVAL RESEARCH LABORATORY - 1980

I. INTRODUCTION

In January 1980, the Health Physics Staff established the environmental monitoring program at the Naval Research Laboratory. There are three main objectives of this program. The first is to monitor the gamma background radiation at the perimeter of the Laboratory, second is to monitor locations around buildings within the Laboratory where gamma radiation levels are suspected of being higher than natural background due to the type of work being carried on in these buildings, and the third objective is to insure that the Laboratory remains in compliance with Title 10, Code of Federal Regulations, Part 20, Standards for Protection Against Radiation. This regulation prohibits a Nuclear Regulatory Commission licensee from producing radiation levels in an unrestricted area which could result in an exposure of two millirems in any one hour or one hundred millirems in any seven consecutive days to the whole body of an individual continuously present in that area. In addition, the total radiation exposure in an unrestricted area is not to exceed 500 millirems in any calendar year. Meeting these present requirements may not be adequate in the future because current philosophy is to limit radiation exposures to as far below the specified limits as practicable and the trend in revising the exposure limits is to lower them substantially (1).

In addition, we hope to identify the major sources of background radiation at the Laboratory and compare the dose which was determined by the environmental dosimeters to the expected annual radiation dose for this area. An attempt will be made to explain any large discrepancies between the annual background radiation dose expected and that which was measured.

II. NATURAL BACKGROUND RADIATION

Natural background radiation comes from three main sources: cosmic radiation, terrestrial radiation, and cosmic-ray produced radionuclides.

Cosmic radiation originates in interstellar space and consists mostly of high energy protons. The energy spectrum ranges from 1 to 10^{14} MeV with the spectrum peaking around 300 MeV. Primary cosmic-ray particles with energies >20 MeV are believed to be of galactic origin, while the

Manuscript submitted May 7, 1981.

majority of the particles with energies below 20 MeV are of solar origin (2). The radiation that reaches the earth is caused by secondary cosmic rays which are produced when the primary cosmic rays interact with nuclei of atoms present in the atmosphere. Due to the relatively low energy of the solar cosmic rays, very little radiation reaches the earth's surface from solar activity.

Terrestrial radiation is the result of naturally occurring radioactive materials which have been present in the earth's crust since its creation. These primodial radionuclides include Uranium (^{238}U), thorium (^{232}Th) and their daughter products, and Potassium (^{40}K), which decays to the stable isotope of calcium. The concentrations of these isotopes vary, depending on the type of rock or the processes which have been involved in the formation of the soil (2,4). Therefore, the annual terrestrial contribution to background radiation can vary significantly from location to location.

Cosmic-ray produced radionuclides contribute only a small amount to the annual background dose. This small amount of background radiation comes from the radioactive isotopes which are produced by the interaction of cosmic rays with the nuclei of atoms in the atmosphere. The most important of these are ^{3}H, ^{7}Be, ^{14}C, and ^{22}Na. These nuclides, when ingested, are the most significant contributors to internal background exposure. The annual exposures from each of these isotopes is estimated to be 0.001, 0.008, 1.3, and 0.02 mRem respectively. The use of nuclear power reactors is increasing the amounts of ^{14}C and ^{3}H present in the atmosphere as well as adding ^{85}Kr (2,5).

The natural background radiation expected for the Washington, D.C. area is 40 mRem/person each year from cosmic radiation; 55 mRem/person each year from terrestrial radiation, and a small contribution of <2.0 mRem/person each year from cosmic-ray produced radionuclides (3). For the purposes of this report, we will only use the values of the cosmic radiation and the terrestrial radiation combined to equal 95 mRem for the year.

III. DOSIMETRY

The detectors used in this study were 30% by weight Calcium Sulfate activated by Dysprosium ($CaSo_4$:Dy) in 12 mm x 0.4 thick teflon discs. They were annealed at 300°C for one hour to stabilize and zero them prior to use. Each dosimeter consists of three detectors sandwiched between 12 mm diameter x 0.7 thick cadmium discs and placed in 0.4 cm thick aluminum holders. The cadmium discs are used to absorb thermal neutrons. Dysprosium has a large thermal neutron cross section (200 barns) and

there is a small contribution to the natural background radiation due to cosmic-ray production of thermal neutrons. The holders were first hermetically sealed in plastic bags and then placed in zip-lock plastic bags as additional protection against moisture prior to putting them out at the monitoring stations. Each monitoring station, with the exception of those along the river, consists of a wooden "bird box" type housing with no front or bottom. The dosimeters along the river were hung on the light poles by copper wire. Each dosimeter was located approximately two meters above the ground.

The dosimeters were collected each quarter and given an annealing for fifteen minutes at 100°C prior to readout to eliminate the low temperature peak and reduce the intial fading. The dosimeters were read on a Harshaw 2000 TLD reader using the following readout schedule: rapid rise in temperature to 100°C, followed by a linear rise at 5°C/min. to 300°C for a total readout time of 60 sec. They were then given a calibration dose using a ^{60}Co source calibrated against a secondary standard ionization chamber which was calibrated by the National Bureau of Standards. Radiation exposures were determined using the average reading of the three discs.

IV. RESULTS

The location of the environmental monitoring sites are shown in Figure 1. These sites were carefully chosen so that not only the natural background radiation could be monitored, but also an evaluation could be made at the areas where radiation work is performed, or where radiation sources are stored. The exposures measured for each quarter and the sum for the year are listed in Table 1.

A statistical analysis was made to compare the readings of dosimeters irradiated in the field to the same dosimeters given calibration doses. This was done to determine if environmental conditions were affecting the accuracy and reproducibility of the results. The standard deviations of the ratios of the three detectors in each dosimeter pack were calculated for both exposure conditions. The results found that there was no significant difference between readings of dosimeters irradiated in the field to those given calibration doses under laboratory conditions (6). This indicates that environmental effects such as heat, humidity, atmospheric pollutants, etc., had little or no effect on the reproducibility of the readings. Several calibration runs made with a set of ten dosimeters, each containing three $CaSo_4$:Dy discs in the same configuration as those used for the survey, determined the reproducibility of each individual disc to be ± 6% (1 S.D.).

The average exposure of all the locations at the Laboratory where only natural background is expected (see Table 1), was 118 ± 7 mR for the year. This compares reasonably with the 95 mR expected. Two locations along the river, numbers 27 and 30, which were not suspected of having a high natural background, had annual doses of 35 mR and 53 mR respectively above the average background reading. These two locations were not used to compute the average background radiation dose and the reason for these high readings is not clear. Further studies will be made to determine the cause of these elevated readings. Each of the remaining locations were chosen because a higher than natural background radiation dose was expected, due either to its proximity to a radioactive source storage area, or to an area where radiation work is being conducted. Locations 1, 2, and 19 were chosen to monitor Building 83 which contains several large Cobalt-60 sources in calibration wells, along with a variety of other radiation sources. With the exception of dosimeter #1, which has no data for one quarter, the other two dosimeters, #2 and #19 read 47 mR and 215 mR above background respectively.

The radioactive source storage area at Building 73 was monitored at locations 3 and 4. Dosimeter #3 had a reading of 23 mR greater than background, while dosimeter #4, which was outside the wall adjacent to where the radioactive sources were stored, had a reading of 178 mR above background for the year. These locations have been changed from Building 73 to Building 89, where the new source storage area has been located.

Two locations near Building 71 were monitored during the year. Location 16, outside the door behind the hot cells of Metallurgy (71-M), had a reading of 99 mR above background, and location 17, outside the door directly adjacent to the Gamble II facility at the High Temperature Lab (71-HTL), had a reading of 61 mR above background.

Location 18, which had a reading of 199 mR above background, was chosen to monitor the Cobalt-60 well and the Van de Graaff facility in Building 5. It was found that most of the radiation received by the dosimeter was primarily due to the operation of the Van de Graaff facility when the beam was deflected at a right angle in the direction of the river (see Figure 1).

V. CONCLUSION

The results of the environmental radiation monitoring program at the Laboratory during the calendar year 1980 show that the Laboratory has met the requirements of the applicable regulations. The fence line monitoring program is continuing and will be adapted to meet future regulatory requirements, and to monitor changes in radiation work areas at the Laboratory. Replacing the $CaSo_4$:Dy discs with LiF chips, mounted in cards like the NRL personnel monitoring badge, is being considered if tests indicate that this will improve our monitoring capabilities.

VI. ACKNOWLEDGMENTS

The author is grateful for the assistance of Tom Johnson and Steve Gorbics of the Staff in preparing this report.

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Table 1 — Environmental monitoring results

Location	Jan-Apr	Apr-July	July-Oct	Oct-Dec 31	Total	Location
1	56	26.5	Missing	47.7	130.2(1)	83
2	65.3	36.2	24.7	39	165.2	83
3	39.2	21.2	44	34.7	139.1	73 Source Storage
4	80.4	76.8	109.6	29.2	296	73
5	31.9	21.1	25.3	39.9	118.2(2)	
6	54.3	20.3	25.0	35	134.6	75 Linac
7	44.6	30.8	38.9	33.5	147.8	75 Linac
8	36.3	33.8	37.2	36.2	143.5	75 Linac
9	37.8	42	26.6	38.6	145(2)	
10	27.2	35	23.3	35.1	120.6(2)	
11	21.4	26.6	23.5	42.2	113.7(2)	
12	25.7	32.2	25.8	34.7	118.4(2)	
13	28.7	34.5	23.8	49.8	136.8(2)	
14	32.7	21	23.9	33.6	111.2(2)	
15	32.5	26.3	25.9	37.1	121.8(2)	
16	71.3	49.6	55.4	40.2	216.5	71M
17	73.0	25.6	24	55.8	178.4	71 HTL
18	47.4	143.2	72.2	54.3	317.1	5 ^{60}Co
19	169.9	67.6	42.8	53.1	333.4	83 Back
20	35.8	24.6	22.2	34.3	116.9(2)	
21	14.1	25.8	34.2	39.4	113.5(2)	256
22	18.9	27.2	18.8	35.1	100.0(2)	256
23	19.6	27.7	20.9	46.3	114.5(2)	256
24	19.0	18.8	22.4	32.7	92.9(2)	256
25	16.3	30.4	19.0	53.4	119.1(2)	256
26	53.4	Missing	30.1	29.3	112.8(1)	River
27	55.3	23.3	30.4	44.4	153.4	River
28	18.4	38.6	32.2	30.1	119.3(2)	River
29	42.9	25.9	19.1	40.8	128.7(2)	River
30	49.6	35.5	37.3	48.4	170.8	River

Average of Background = 118 mR
(1) Data computed for three quarters
(2) Data used to compute the background average = 118 mR/year (1980)

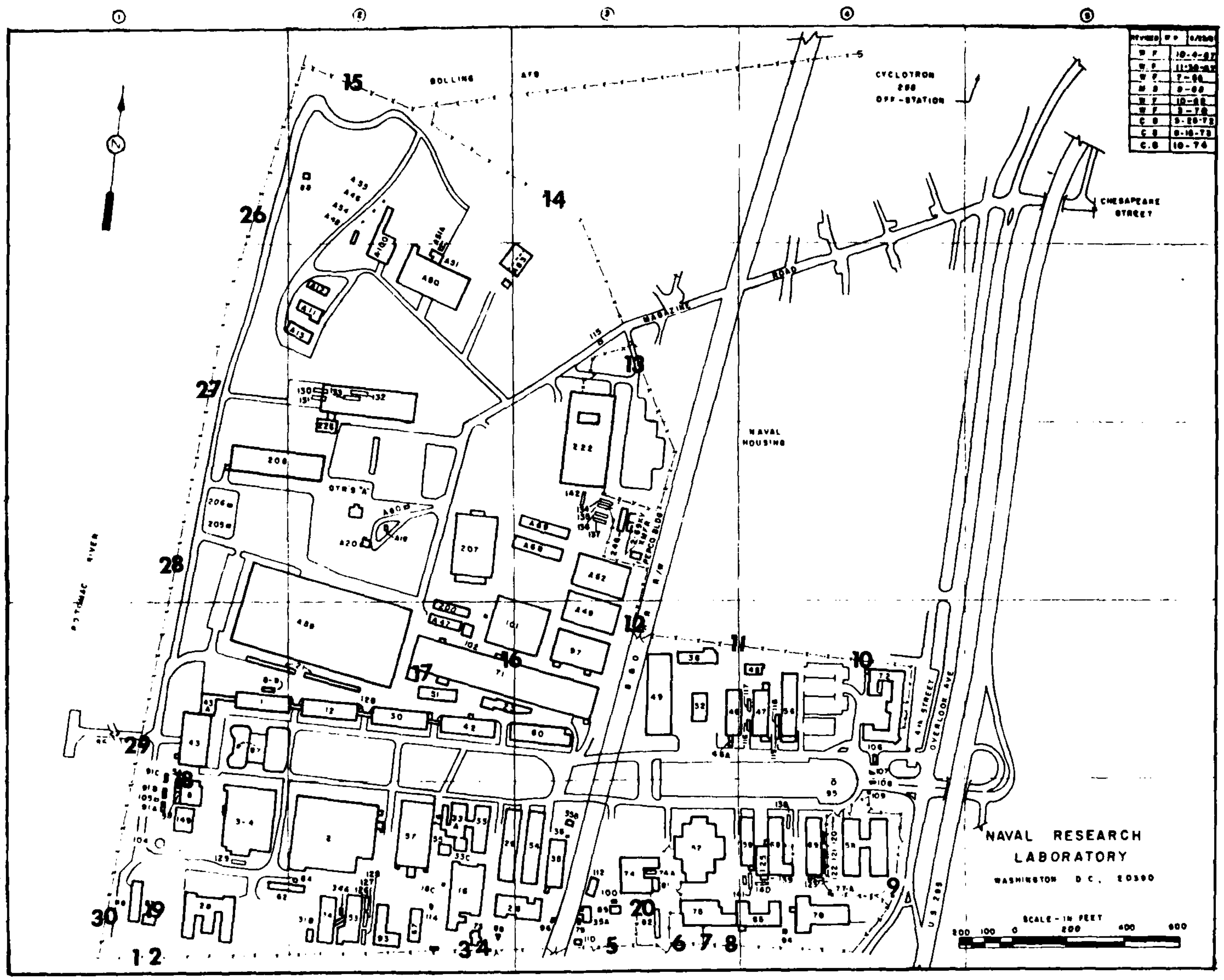

Fig. 1 — Location of environmental radiation monitors